extent possible our botanic gardens and museums. I would not look upon them as a mere adjunct to our work or as factors in a method of teaching, but I would connect them as an integral part of the subject and in one sense the most important part. If the training and botanical knowledge that we give to our pupils is going to amount to anything it must not stop at the end of the first year course in elementary botany. How then are we going to continue it, especially with those pupils who cannot go to college? The answer is, teach them how to use the gardens and the parks. Teach them so that in later years and even during the rest of their high school course, they may find in them a place for recreation and a source of inspiration, a means of avocation, and in some cases, let us hope, a field for serious study. What the public libraries are to the English and history departments, the gardens, parks and museums should be to the biology department.

In conclusion let me say that though the present outlook is none too bright, and we may have to fight for the very existence of our subject, the future is not hopeless. If we believe in our subject let us vitalize it. Let it meet the needs, solve the problems and arouse the interests of our pupils. If we do this, if we vitalize it properly, botany will compel its own recognition.

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CHANGES IN TEACHING BIOLOGY IN OUR HIGH SCHOOLS

By Cyrus A. King

To graduate from a city high school, a pupil is required to pass and receive credit for 17 units of work. Of these units, eight are required of all pupils. Three are in English, three in history and civics and two are given for work in drawing and physical training. The other nine units are selected from the following groups: Three from a foreign language group, two from another language group, two from the mathematics or science group, and the remaining two from any group.

This seems an admirable arrangement, and at first glance, one might think it offered a wide range of selection to suit the individual wishes of different students. However, when we consider the traditions of the high schools, and the still more rigid traditions of our eastern colleges, we find that the sciences are *practically* cut off from our best class of pupils, the ones who intend to go to our higher institutions, and who, in consequence, are ultimately to be our most influential citizens.

I propose to illustrate this by selecting three typical examples. Let us suppose that a boy wishes to prepare for an engineering school. In addition to his eight credits, which are required, he selects a language and carries it three years; this leaves *six* units. Our best engineering schools require four years of preparatory work in mathematics; this leaves *two* units. These are usually taken in physics and chemistry because they are often required. This boy has no chance to select the biological sciences, unless he takes them as extra subjects.

Let us now take the case of a girl who wishes to enter one of the better girls' colleges, for example, Mt. Holyoke, Smith, Vassar or Wellesley. In addition to the eight required units, she must have *four* units in Latin, at least *two* in a second language, and *two and a half* in mathematics. This leaves one half point for science work.

For the third illustration, we will select a pupil who does not intend to go to college. The traditions of most of the academic schools will cause him to elect a modern language, which he will carry for three years; he will also take at least two years of mathematics; this leaves four units to be selected from a second language, from courses in stenography and typewriting, and from the different sciences. Let us suppose that he selects two sciences the question is shall one of them be a general course or a course in biology.

The biology courses that are now offered in our city high schools are, relatively speaking, new. They have no inheritance and no traditions. Unlike Greek, Latin and mathematics, they have not occupied for centuries an important place in our educational institutions. They are so new that we have scarcely

had time to stabilize them. However, there has never been such an age as the present. Days count almost as years of certain earlier periods. Under such conditions, a modern subject is rapidly adapted to our educational needs. Furthermore, biology certainly has the merit of having had no opportunity to become fossilized.

Our elementary course in biology was born about 1900, was revised thoroughly in 1905, again in 1910, and a new revision has just come from the press. The advanced course in biology was approved three or four years ago. It is now undergoing a revision.

During this interval of twenty years, the aims of the course have broadened and the work became more definite. And now at the end of this time, when we have the best courses that we have ever had, when we have a corps of highly trained efficient teachers, and know that ours is one of the most valuable subjects in the whole curiculum, it is actually being forced out of the schools for a conglomeration of every thing in kingdom come which for lack of a better name is called general science. The New York City schools are now teaching general science without a syllabus and without specially trained teachers.

I have looked over about a dozen text-books in general science, some good, some fair, and some poor, and have the honest conviction that the subject, at the present time, is not well organized.

True to their name, our biology courses center about life and living things. *Their aim is to teach the fundamental principles of life and it is impossible to develop these principles in the limited time given to the subject in a general science course.* To accomplish this it is necessary to study a number of forms that are widely different. This is why we have put into our courses a considerable amount of plant study, a somewhat less amount of animal study, and, finally, a study of man with an application of these principles to him. We believe that a pupil who has proved that respiration takes place in germinating seeds, that it takes place in higher plants, that it is necessary in the life of the paramecium, who understands how the insects, the fish and the frog are adapted for breathing, and who knows something of the organs

of respiration in man and their adaptations, sees a deeper meaning in respiration as a vital process. The same thing applies to the great facts of sex reproduction, inheritance, and eugenics. Our course requires that we work with living things that throw light on the fundamental problems of life.

At the risk of being called old fashioned, I do not hesitate to say that the foregoing kind of work is the most important that can be offered in any course in biology. And what are the reasons for not having such a course in every high school? What kind of an education is it that fails to recognize the value of the study of man as a living organism. Mentally and physically, he is the center of all education and he is unified with and bound to these lower organisms by the laws of life. Furthermore, if an additional argument were needed, we know that the study of plants and animals trains him in observation, develops his judgment, give him the method to reason logically, and finally furnishes him with important information about himself. It also opens up a new living world that he will appreciate all his life.

Recently a father, who by the way is a strong advocate of general science, said to me: "Your biology work is not making good." I asked him why he thought so and he said that his daughter had taken the course for a year and did not know the names of the trees on the block where they live. This, in his opinion was a serious criticism. My answer to this is that our course requires that we place the emphasis chiefly on important biological problems and that this leaves little time for such superficial work as learning names, even though this is desirable. However, before passing in the course, that daughter had to know the general structure of a root, the way it gets water from the soil, and she had seen this illustrated in the laboratory. She had to know the course of the water through the root, stem, and leaves; and she had seen experimental proof of this. She learned by experiment how plants give off water and something of how food is manufactured. She knew, too, that this tree took in and gave off certain gases and the reason for this exchange. This incident illustrates the type of criticism that we are receiving. In the main, it comes from persons who have no con-

ception of the value of our work, who are more or less antagonistic to it, or who have their ears on the ground listening for something new.

A second aim of the course, is to emphasize the relation of biology to human welfare. This brings out the commercial importance of plants and animals and our dependence upon them; especially upon plants. It is a revelation to our city boys and girls to find that the *annual* value of our *corn* crop is greater than any *liberty loan except the fourth*, and to learn that our wheat and oats crop in 1917 were about two billion dollars *each*. Only after they realize the tremendous importance of our crops, do they appreciate the damage done by plant diseases and insect pests. One writer, for example, estimates that the hessian fly and the wheat rust *each* destroy one tenth of the crop. While this may be an exaggeration, it nevertheless suggests the importance of biology to our daily life. It is an introduction to the study of agriculture in its various phases, to pharmacy, to dentistry, and to medicine, and it also interests them in the laws of inheritance and in plant and animal breeding.

The study of bacteria gives a second important relation to human welfare. The names and structure of bacteria are of little importance to our pupils. But it is important that they know the conditions under which bacteria thrive well and the conditions that cause their death. Pupils should know how abundant they are, and the common ways of distributing them. These lessons are necessary to emphasize the third point in my paper and that is that our biology courses are an excellent training for citizenship.

Twelve years ago, when the American association met here in New York, one of the foremost biologists in this city read a paper in which he emphasized the importance of biology in the development of citizenship. While I will confess to you that I had not, up to that time, thought of our courses as especially valuable in this respect, I have never since lost sight of its possibilities.

Heretofore, I have been quite willing to let the philosophers and the theorists discuss the subject matter best adapted for the development of citizenship. The subject belongs largely in the

field of the general and the abstract where the philosopher revels.

It is my opinion that the biological sciences can supply excellent material for the development of citizenship and I propose to offer some definite suggestions that show what we can contribute to this work. A citizen is a person who is born in the United States or who has been naturalized here, who owes allegiance to *his* country, *his state*, and *his city*, and who is entitled to their protection. The opposite to a *citizen* is an *alien*. Our war has emphasized the importance of eliminating the aliens and educating the citizens.

Mention has been made that we teach the importance of bacteria in relation to human welfare. Our pupils know the danger of infection from milk, why unsanitary stables are a menace and why the men working in the stables should not come from homes where there are communicable diseases. They know that milk should be subjected to a low temperature at once, why it should be Pasteurized, and the care it should have while on the way to the city. This is equally true of meats and vegetables. Our pupils know the danger from inattention to the water supply. They appreciate the importance of clean streets. Their knowledge of epidemic diseases will cause them to favor and insist upon an efficient board of health. They have sane reasons for supporting regulations relating to quarantine vaccination and disinfection. They have a more intelligent interest in the care of our parks and the trees of the city. Such educational institutions as the botanical gardens and the American museums will get their hearty support for they appreciate what these institutions stand for. They have a more intelligent interest in, and a greater loyalty for their city. They are better equipped to assume the duties of citizenship.

It is possible that the advocates of general science, who by the way, are chiefly teachers of physics and chemistry, will tell you that their course does all this and a great deal more. My answer is that it would be better to have two years to do the work outlined in biology. When they give the biology work a minor place in a year's course, they simply mutilate it. Pupils grasp

the great questions of life only after having studied them in a reasonably wide range of individuals. In comparing the value of the two courses, do not lose sight of the fact that our work is a matter of record and we are perfectly willing to be fairly judged by what we have done and are doing. Theirs is all theory and argument. I have never heard a general science advocate give a concise, constructive argument for its substitution for biology. They will tell you that it has made good in the West, and that it is spreading everywhere. There are several reasons why I am not much impressed with that argument. First, the West is a long way off and it is not possible to get definite facts as to how successful their work is. Second, the universities of the Middle West are less exacting in their conditions for admission. This leaves plenty of time for three or four years in science courses. Such conditions will offset the handicap of one inferior course. In the third place, I have personally admitted to our courses pupils who have been trained in general science in schools at Minneapolis, Chicago, Washington, D. C., Massachusetts, Connecticut, Pennsylvania and New Jersey. This list includes one pupil who was taught by the author of one of the well-known books in general science. In every instance, I examined the laboratory note book, in case the pupil made one, and the results make me more emphatic in saying that general science, as taught at the present time, is not well organized.

And now, in conclusion, to revert to the title of my paper, the changes that I would suggest are not so much the content of the course as the question of emphasis. I would urge, first, more time on the fundamental processes of living things. This is the most important part of the work and unless we get our pupils to understand them, by teaching them over and over again, we will lower our course until it is on a level with general science. Second, wherever possible, I would teach these principles by means of forms that have an important relation to human welfare. Third, I would emphasize facts in our course that train for citizenship.

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